

OIL REFINERY PROCESSES

A BRIEF OVERVIEW

Group assignment presentation

Some Historical Events

- 3000 BC Sumerians use asphalt as an adhesive; Egyptians use pitch to grease chariot wheels; Mesopotamians use bitumen to seal boats
- 600 BC Confucius writes about drilling a 100' gas well and using bamboo for pipes
- 1500 AD Chinese dig oil wells >2000' deep
- 1847 First "rock oil" refinery in England
- 1849 Canada distills kerosene from crude oil
- 1856 World's first refinery in Romania
- 1857 Flat-wick kerosene lamp invented
- 1859 Pennsylvania oil boom begins with 69' oil well producing 35 bpd
- 1860-61 Refineries built in Pennsylvania and Arkansas
- 1870 US Largest oil exporter; oil was US 2nd biggest export
- 1878 Thomas Edison invents light bulb
- 1901 Spindletop, Texas producing 100,000 bpd kicks off modern era of oil refining
- 1908 Model T's sell for \$950/T
- 1913 Gulf Oil opens first drive-in filling station
- 1942 First Fluidized Catalytic Cracker (FCC) commercialized
- 1970 First Earth Day; EPA passes Clean Air Act
- 2005 US Refining capacity is 17,042,000 bpd, 23% of World's 73MM

1876 California Oil Refinery

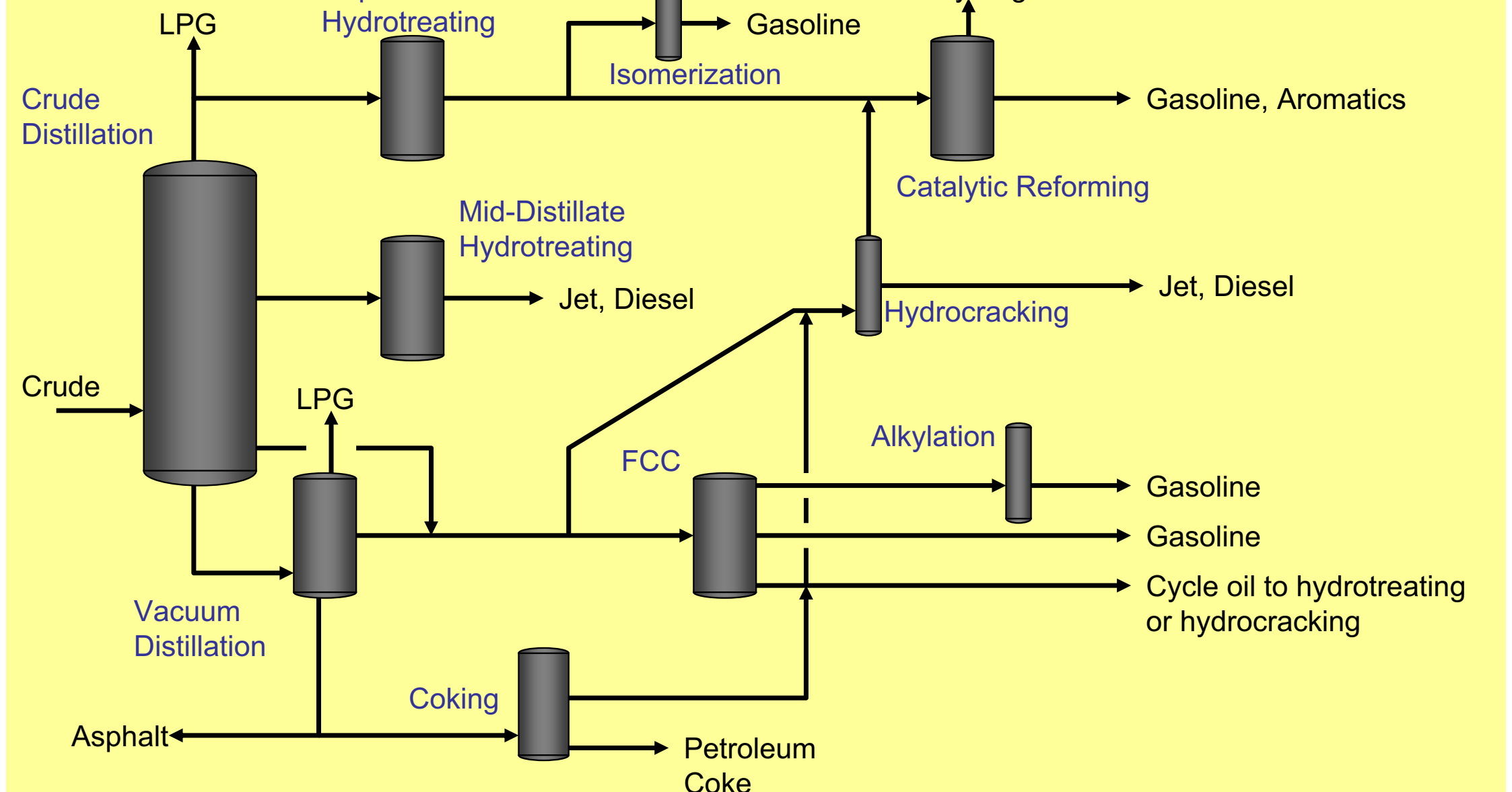


What is Petroleum?

- A complex mixture containing thousands of different organic hydrocarbon molecules
 - 83-87% Carbon
 - 11-15% Hydrogen
 - 1-6% Sulfur
- Paraffins – saturated chains
- Naphthenes – saturated rings
- Aromatics – unsaturated rings

Naphtha

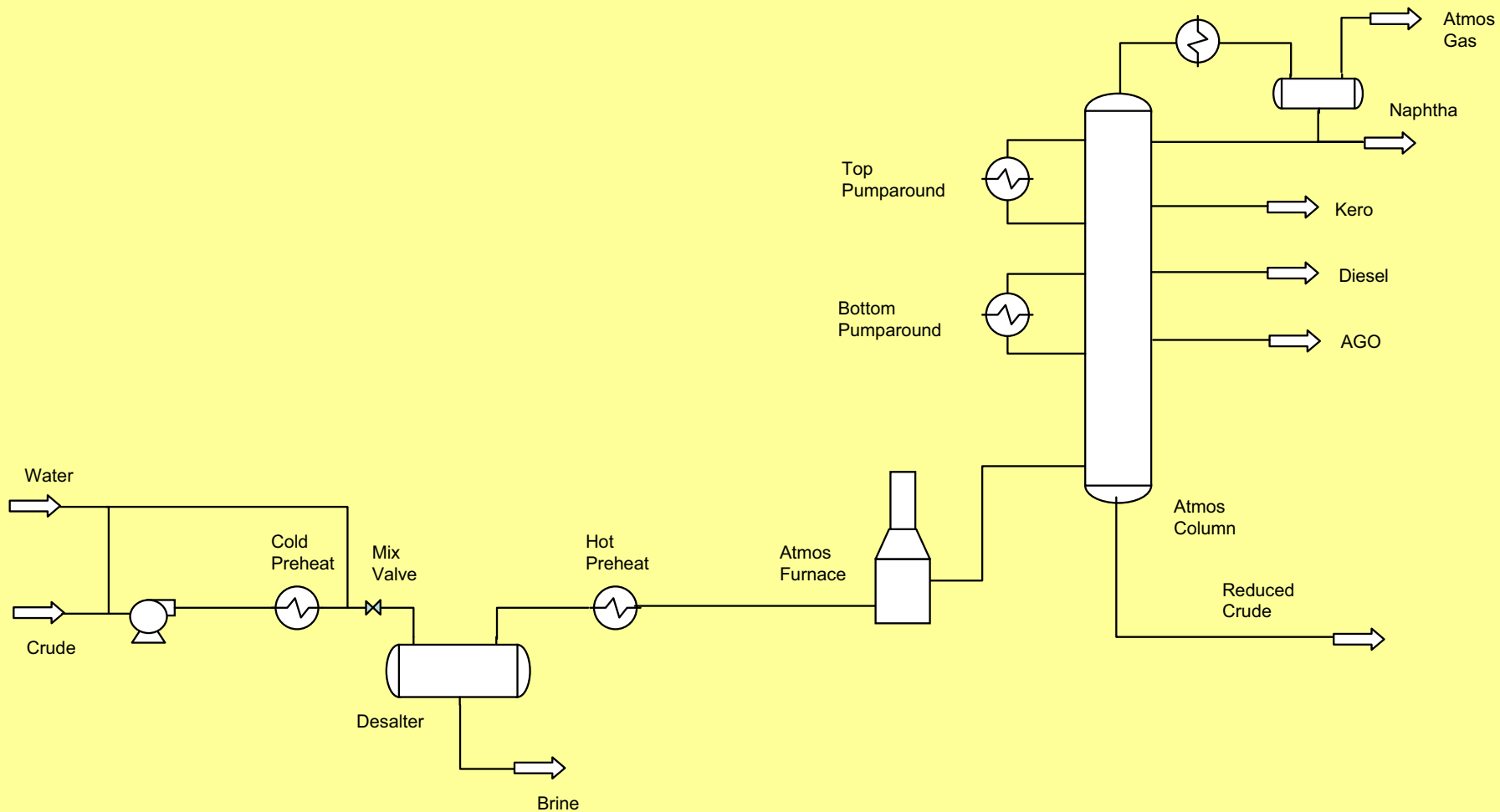
Hydrogen



CDU Process

- Process Objective:
 - To distill and separate valuable distillates (naphtha, kerosene, diesel) and atmospheric gas oil (AGO) from the crude feedstock.
- Primary Process Technique:
 - Complex distillation
- Process steps:
 - Preheat the crude feed utilizing recovered heat from the product streams
 - Desalt and dehydrate the crude using electrostatic enhanced liquid/liquid separation (Desalter)
 - Heat the crude to the desired temperature using fired heaters
 - Flash the crude in the atmospheric distillation column
 - Utilize pumparound cooling loops to create internal liquid reflux
 - Product draws are on the top, sides, and bottom

Crude Distillation Unit (CDU) Process Schematic



CDU Process

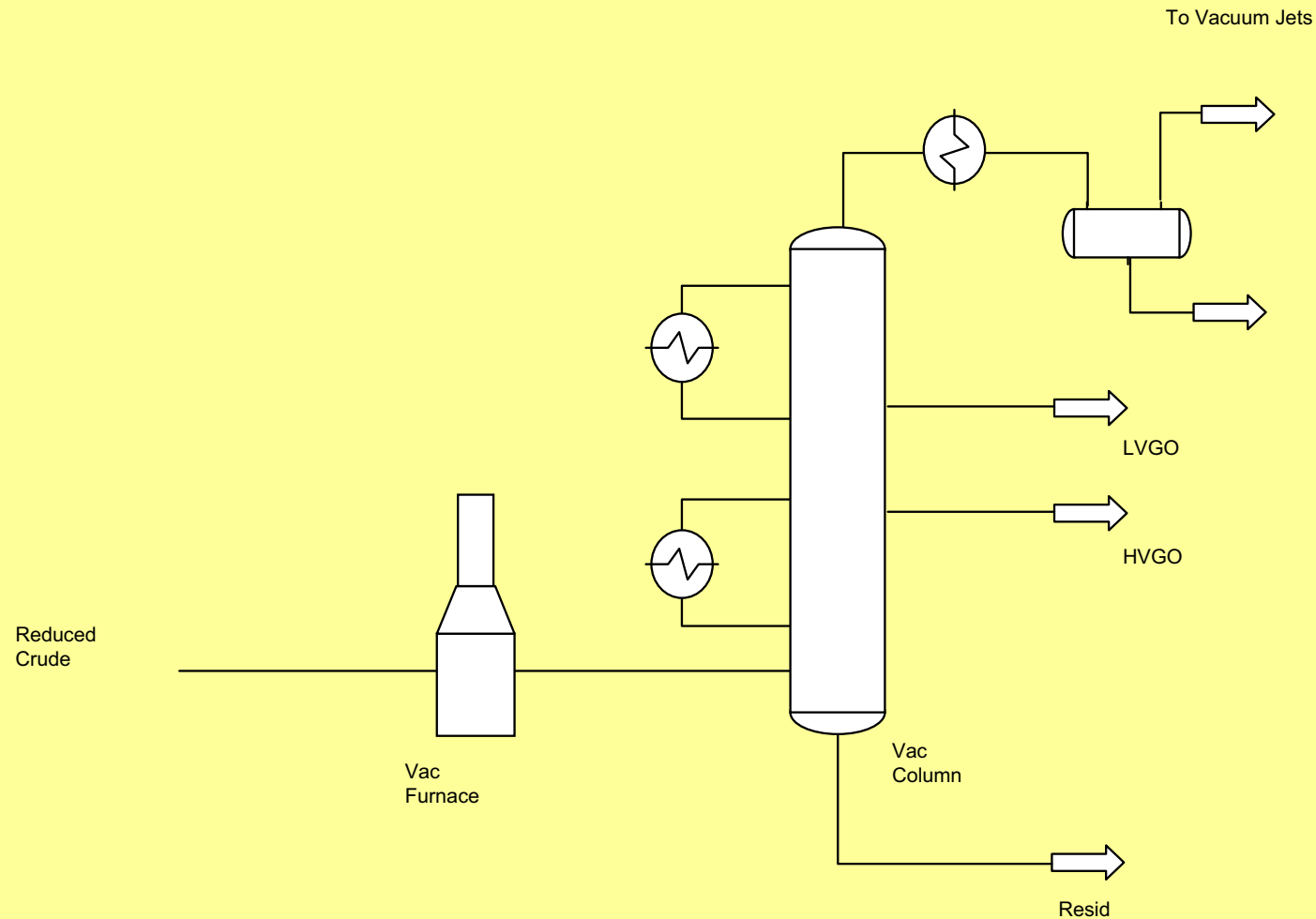
- Typical Yields and Dispositions

<u>PRODUCT</u>	<u>Yield, wt% of Crude</u>	<u>Disposition</u>
Light Ends	2.3	LPG
Light Naphtha	6.3	Naphtha Hydrotreating
Medium Naphtha	14.4	Naphtha Hydrotreating
Heavy Naphtha	9.4	Distillate Hydrotreating
Kerosene	9.9	Distillate Hydrotreating
Atmospheric Gas Oil	15.1	Fluid Catalytic Cracking
Reduced Crude	42.6	Vacuum Distillation Unit

VDU Process

- Process Objective:
 - To recover valuable gas oils from reduced crude via vacuum distillation.
- Primary Process Technique:
 - Reduce the hydrocarbon partial pressure via vacuum and stripping steam.
- Process steps:
 - Heat the reduced crude to the desired temperature using fired heaters
 - Flash the reduced crude in the vacuum distillation column
 - Utilize pumparound cooling loops to create internal liquid reflux
 - Product draws are top, sides, and bottom

Vacuum Distillation Unit (VDU) Process Schematic



VDU Process

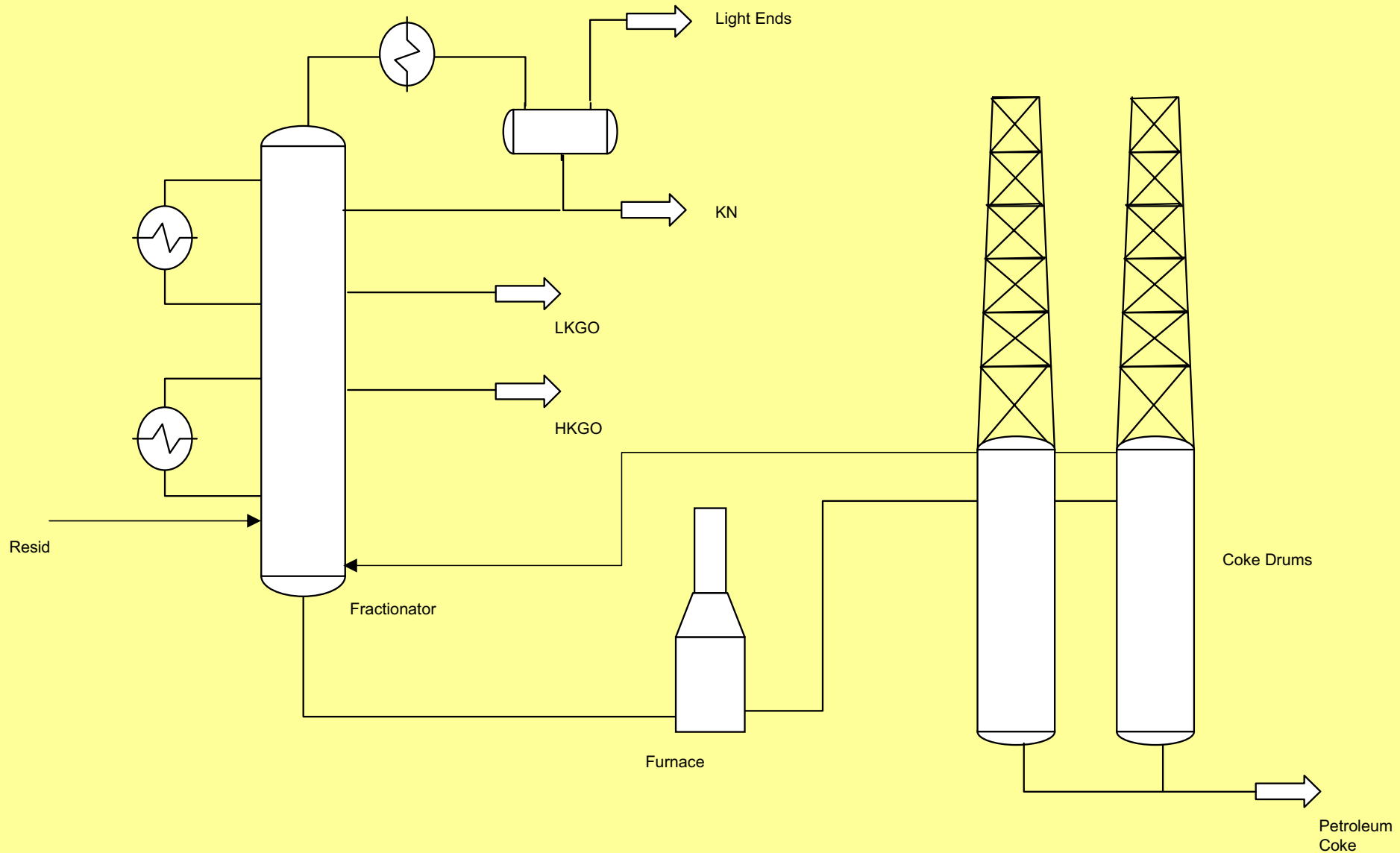
- Typical Yields and Dispositions

<u>PRODUCT</u>	<u>Yield, wt% of Crude</u>	<u>Disposition</u>
Light Ends	<1	LPG
Light VGO	17.6	Distillate Hydrotreating
Heavy VGO	12.7	Fluid Catalytic Cracking
Vacuum residue (Resid)	12.3	Coking

Delayed Coking Process

- Process Objective:
 - To convert low value resid to valuable products (naphtha and diesel) and coker gas oil.
- Primary Process Technique:
 - Thermocracking increases H/C ratio by carbon rejection in a semi-batch process.
- Process steps:
 - Preheat resid feed and provide primary condensing of coke drum vapors by introducing the feed to the bottom of the main fractionator
 - Heat the coke drum feed by fired heaters
 - Flash superheated feed in a large coke drum where the coke remains and vapors leave the top and goes back to the fractionator
 - Off-line coke drum is drilled and the petroleum coke is removed via hydrojetting

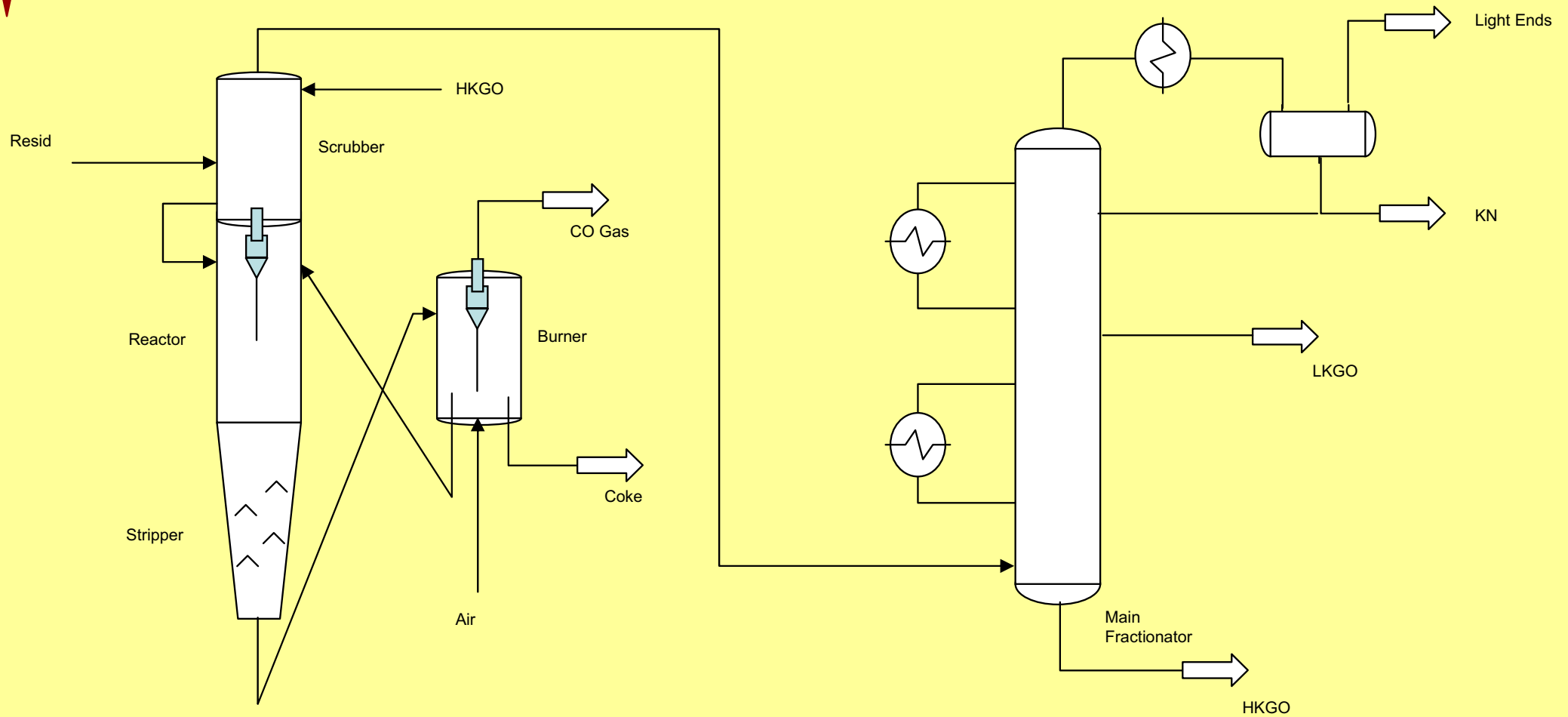
Delayed Coking Process Schematic



Fluidic Coking Process

- Process Objective:
 - To convert low value resid to valuable products (naphtha and diesel) and coker gas oil.
- Primary Process Technique:
 - Thermocracking increases H/C ratio by carbon rejection in a continuous process.
- Process steps:
 - Preheat resid feed, scrub coke particles, and provide primary condensing of reactor vapors by introducing the feed to the scrubber
 - Resid is atomized into a fluid coke bed and thermocracking occurs on the particle surface
 - Coke particles leaving the reactor are steam stripped to remove remaining liquid hydrocarbons
 - Substoichiometric air is introduced to burner to burn some of the coke and provide the necessary heat for the reactor
 - Reactor vapors leave the scrubber and go to the fractionator

Fluidic Coking Process Schematic



Delayed & Fluid Coking Processes

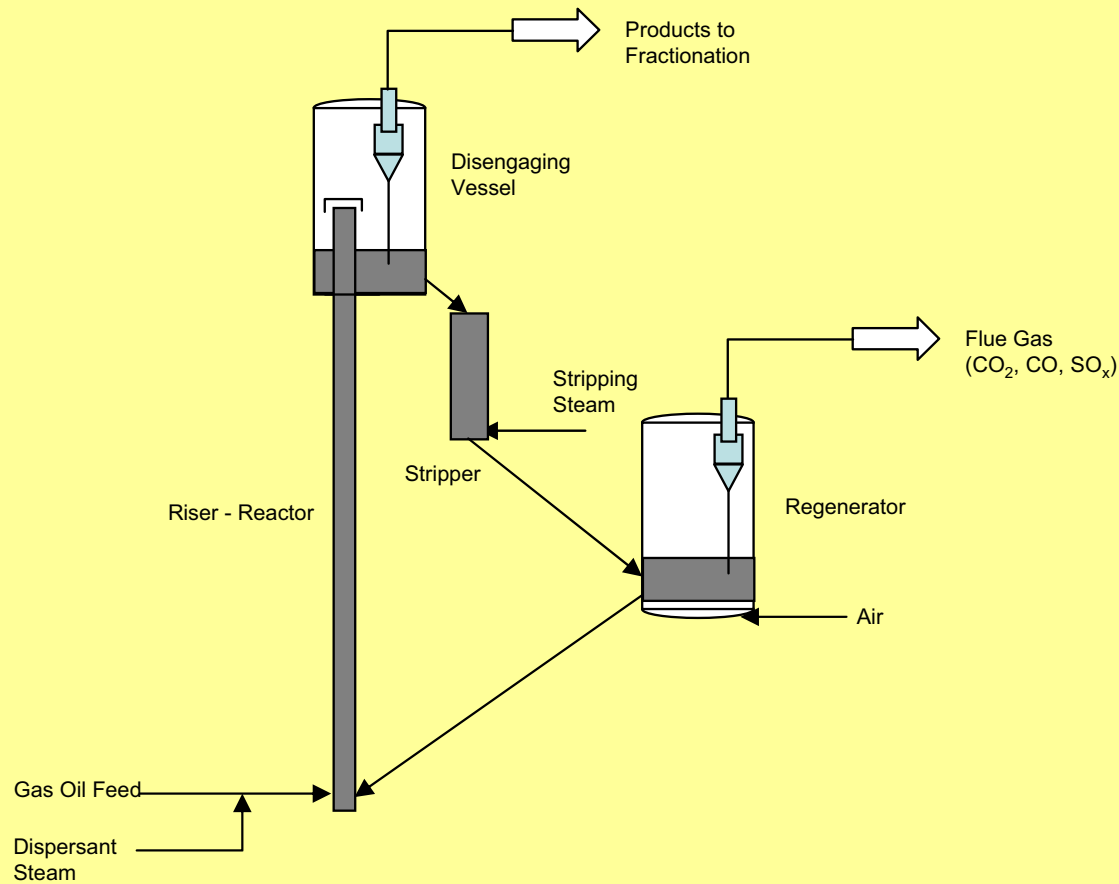
- Typical Yields and Dispositions

<u>PRODUCT</u>	<u>Yield, wt% of feed</u>	<u>Disposition</u>
Light Ends	12.5 – 20	LPG
Naphtha	10 – 15	Naphtha Hydrotreating
Light Coker Gas Oil	18 – 24	Distillate Hydrotreating
Heavy Coker Gas Oil	30 – 40	Fluid Catalytic Cracking
Pet. Coke	20 - 35	Sponge – carbon anodes; Needle – graphite electrodes; Any coke – power generation

FCC Process

- Process Objective:
 - To convert low value gas oils to valuable products (naphtha and diesel) and slurry oil.
- Primary Process Technique:
 - Catalytic cracking increases H/C ratio by carbon rejection in a continuous process.
- Process steps:
 - Gas oil feed is dispersed into the bottom of the riser using steam
 - Thermal cracking occurs on the surface of the catalyst
 - Disengaging drum separates spent catalyst from product vapors
 - Steam strips residue hydrocarbons from spent catalyst
 - Air burns away the carbon film from the catalyst in either a “partial-burn” or “full-burn” mode of operation
 - Regenerated catalyst enters bottom of riser-reactor

Fluidic Catalytic Cracking (FCC) Process Schematic



FCC Process

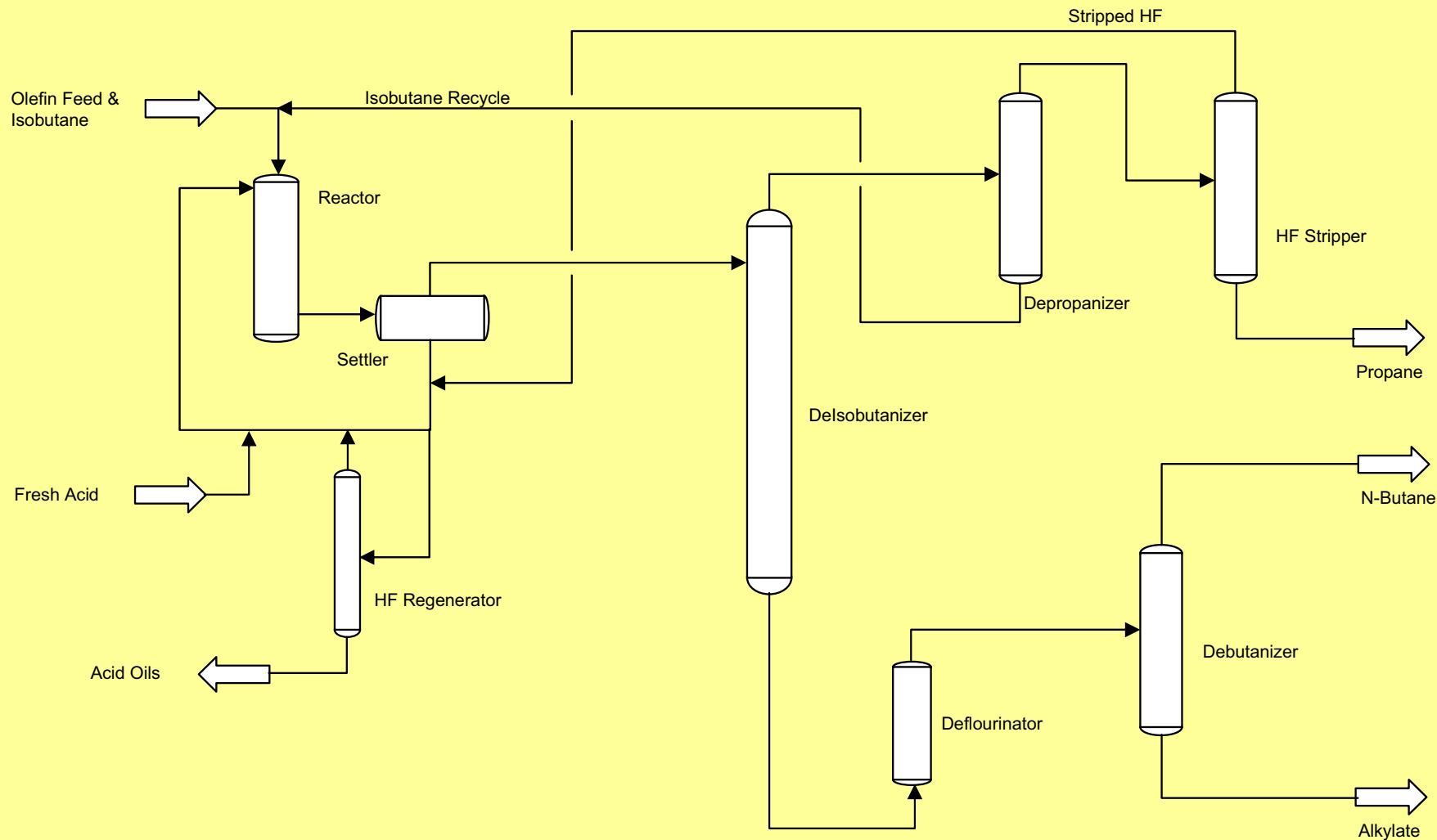
- Typical Yields and Dispositions

<u>PRODUCT</u>	<u>Yield, wt% of feed</u>	<u>Disposition</u>
Light Ends	16.5 – 22	LPG; Alky
Naphtha	44 – 56	Naphtha Hydrotreating
Light Cycle Oil	13 – 20	Distillate Hydrotreating
Medium Cycle Oil	10 – 26	Hydrocracking
Slurry Oil	4 - 12	Heavy fuel oil; carbon black processing
Coke	5 – 6	Flue gas to CO boiler

HF Alkylation Process

- Process Objective:
 - To combine light olefins (propylene and butylene) with isobutane to form a high octane gasoline (alkylate).
- Primary Process Technique:
 - Alkylation occurs in the presence of a highly acidic catalyst (hydrofluoric acid or sulfuric acid).
- Process steps:
 - Olefins from FCC are combined with IsoButane and fed to the HF Reactor where alkylation occurs
 - Acid settler separates the free HF from the hydrocarbons and recycles the acid back to the reactor
 - A portion of the HF is regenerated to remove acid oils formed by feed contaminants or hydrocarbon polymerization
 - Hydrocarbons from settler go to the Delsobutanizer for fractionating the propane and isobutane from the n-butane and alkylate
 - Propane is then fractionated from the isobutane; propane as a product and the isobutane to be recycled to the reactor
 - N-Butane and alkylate are defluorinated in a bed of solid adsorbent and fractionated as separate products

HF Alkylation Process Schematic



HF Alkylation Process

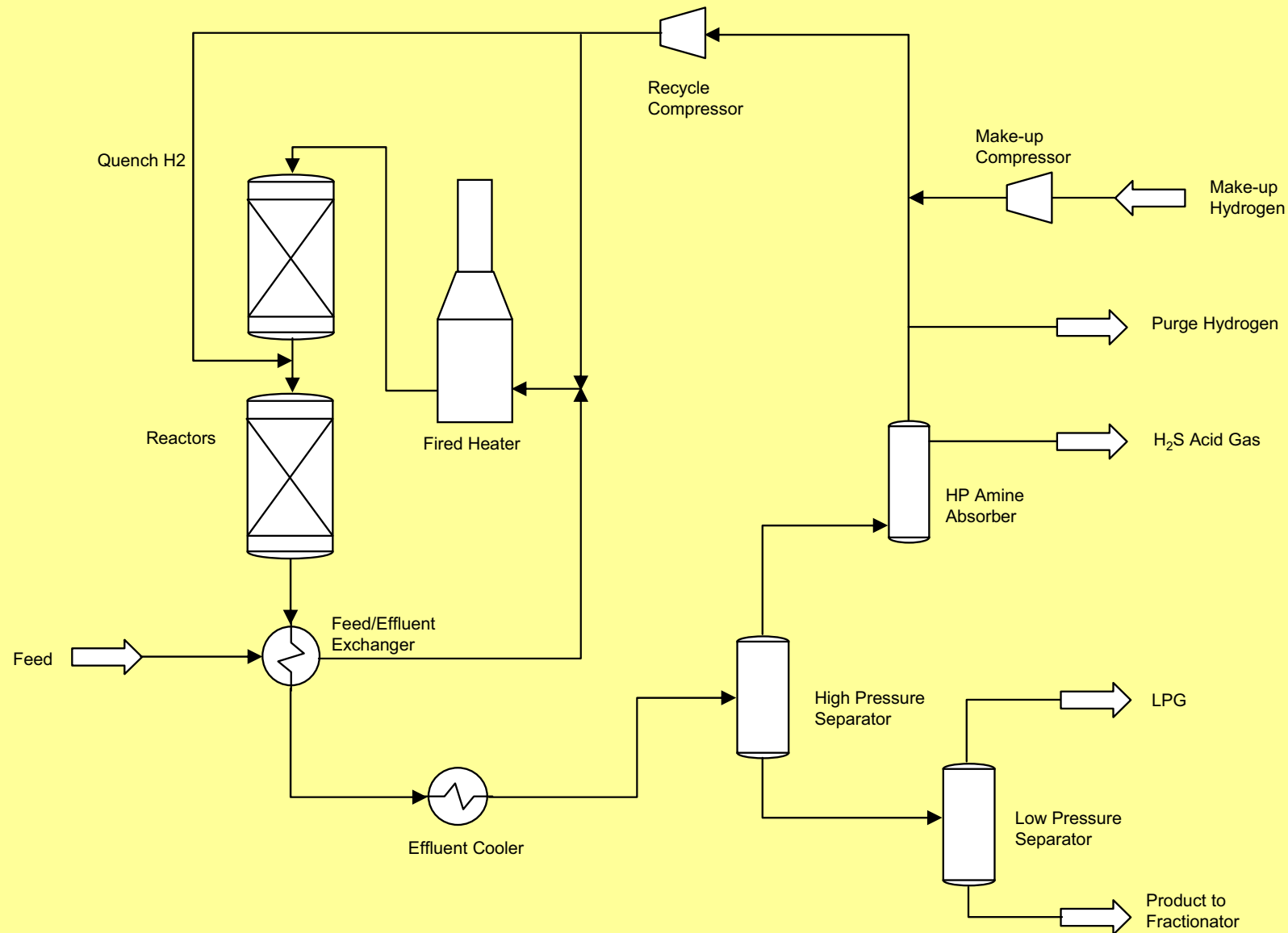
- Typical Yields and Dispositions

<u>PRODUCT</u>	<u>Yield, vol% of olefin feed</u>	<u>Disposition</u>
Propane	20 - 30	LPG
N-Butane	40 - 52	LPG; Gasoline
Alkylate	150 – 170	Gasoline
Acid Oils	<1	Furnace
Isobutane consumption	67 - 75	

Hydrotreating Process

- Process Objective:
 - To remove contaminants (sulfur, nitrogen, metals) and saturate olefins and aromatics to produce a clean product for further processing or finished product sales.
- Primary Process Technique:
 - Hydrogenation occurs in a fixed catalyst bed to improve H/C ratios and to remove sulfur, nitrogen, and metals.
- Process steps:
 - Feed is preheated using the reactor effluent
 - Hydrogen is combined with the feed and heated to the desired hydrotreating temperature using a fired heater
 - Feed and hydrogen pass downward in a hydrogenation reactor packed with various types of catalyst depending upon reactions desired
 - Reactor effluent is cooled and enter the high pressure separator which separates the liquid hydrocarbon from the hydrogen/hydrogen sulfide/ammonia gas
 - Acid gases are absorbed from the hydrogen in the amine absorber
 - Hydrogen, minus purges, is recycled with make-up hydrogen
 - Further separation of LPG gases occurs in the low pressure separator prior to sending the hydrocarbon liquids to fractionation

Hydrotreating Process Schematic



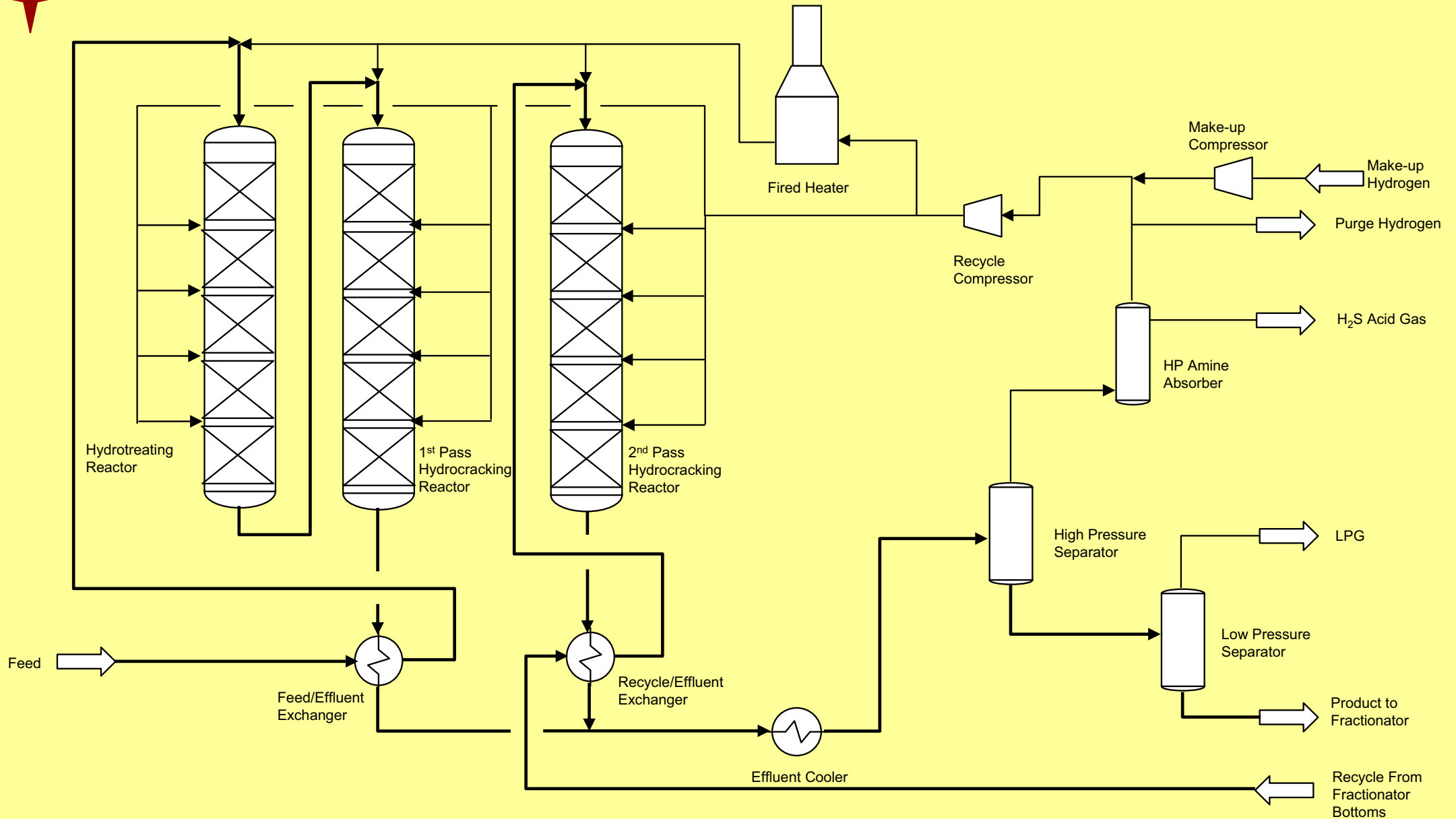
Hydrotreating Process

- Naphtha Hydrotreating
 - Primary objective is to remove sulfur contaminant for downstream processes; typically < 1wppm
- Gasoline Hydrotreating
 - Sulfur removal from gasoline blending components to meet recent clean fuels specifications
- Mid-Distillate Hydrotreating
 - Sulfur removal from kerosene for home heating
 - Convert kerosene to jet via mild aromatic saturation
 - Remove sulfur from diesel for clean fuels
 - Ultra-low sulfur diesel requirements are leading to major unit revamps
- FCC Feed Pretreating
 - Nitrogen removal for better FCC catalyst activity
 - Sulfur removal for SO_x reduction in the flue gas and easier post-FCC treatment
 - Aromatic saturation improves FCC feed “crackability”
 - Improved H/C ratios increase FCC capacity and conversion

Hydrocracking Process

- Process Objective:
 - To remove feed contaminants (nitrogen, sulfur, metals) and to convert low value gas oils to valuable products (naphtha, middle distillates, and ultra-clean lube base stocks).
- Primary Process Technique:
 - Hydrogenation occurs in fixed hydrotreating catalyst beds to improve H/C ratios and to remove sulfur, nitrogen, and metals. This is followed by one or more reactors with fixed hydrocracking catalyst beds to dealkylate aromatic rings, open naphthene rings, and hydrocrack paraffin chains.
- Process steps:
 - Preheated feed is mixed with hot hydrogen and passes through a multi-bed reactor with interstage hydrogen quenches for hydrotreating
 - Hydrotreated feed is mixed with additional hot hydrogen and passes through a multi-bed reactor with quenches for first pass hydrocracking
 - Reactor effluents are combined and pass through high and low pressure separators and are fed to the fractionator where valuable products are drawn from the top, sides, and bottom
 - Fractionator bottoms may be recycled to a second pass hydrocracker for additional conversion all the way up to full conversion

Hydrocracking Process Schematic



Hydrocracking Process

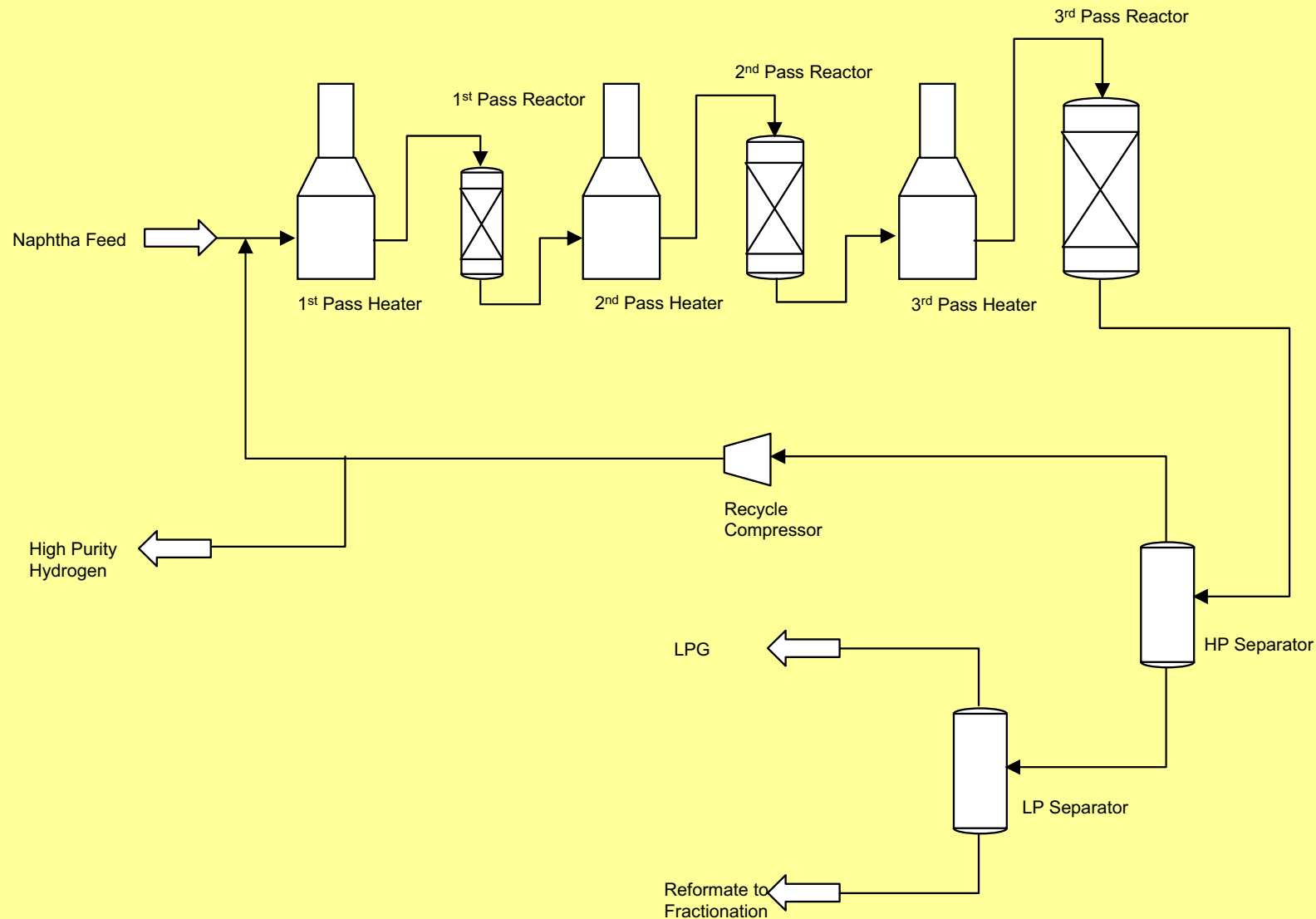
- Typical Yields and Dispositions

<u>PRODUCT</u>	<u>Yield, vol% feed</u>	<u>Disposition</u>
Light ends	Varies depending upon objectives	LPG
Naphtha	“”	Gasoline; Catalytic Reformer
Diesel	“”	Diesel
Total volume yield	130 - 140	
Gas oil conversion	60 – 99%	

Catalytic Reforming Process

- Process Objective:
 - To convert low-octane naphtha into a high-octane reformat for gasoline blending and/or to provide aromatics (benzene, toluene, and xylene) for petrochemical plants. Reforming also produces high purity hydrogen for hydrotreating processes.
- Primary Process Technique:
 - Reforming reactions occur in chloride promoted fixed catalyst beds; or continuous catalyst regeneration (CCR) beds where the catalyst is transferred from one stage to another, through a catalyst regenerator and back again. Desired reactions include: dehydrogenation of naphthenes to form aromatics; isomerization of naphthenes; dehydrocyclization of paraffins to form aromatics; and isomerization of paraffins. Hydrocracking of paraffins is undesirable due to increased light-ends make.
- Process steps:
 - Naphtha feed and recycle hydrogen are mixed, heated and sent through successive reactor beds
 - Each pass requires heat input to drive the reactions
 - Final pass effluent is separated with the hydrogen being recycled or purged for hydrotreating
 - Reformate product can be further processed to separate aromatic components or be used for gasoline blending

Catalytic Reforming Process Schematic



Catalytic Reforming Process

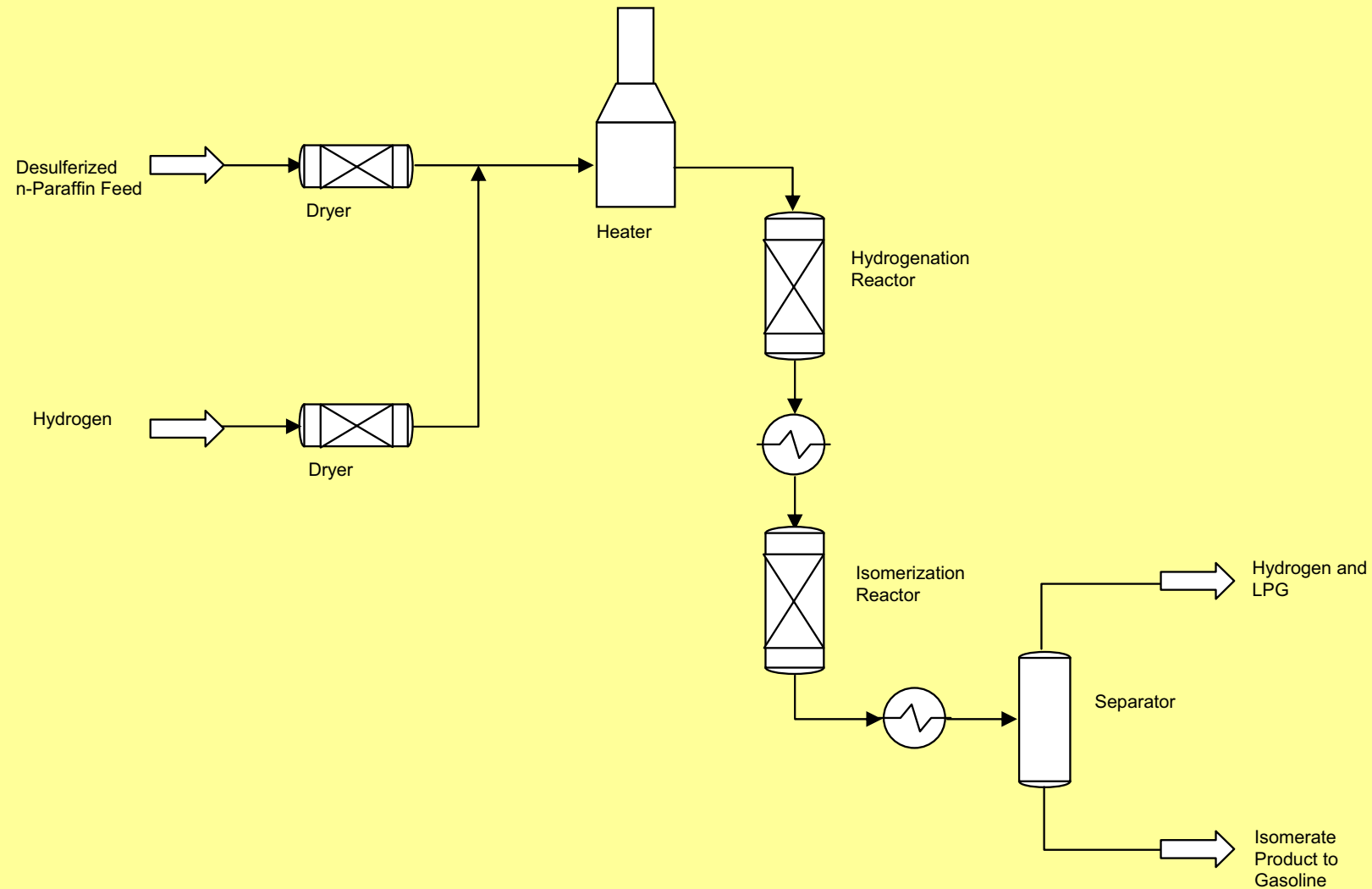
- Typical Yields and Dispositions

<u>PRODUCT</u>	<u>Yield, vol% feed</u>	<u>Disposition</u>
Light ends	5 – 8	LPG
Reformate	84 – 85	Gasoline; Petrochemical Plants
Hydrogen	650 – 1100 scf/bbl	Hydrotreating

Isomerization Process

- Process Objective:
 - To convert low-octane n-paraffins to high-octane iso-paraffins.
- Primary Process Technique:
 - Isomerization occurs in a chloride promoted fixed bed reactor where n-paraffins are converted to iso-paraffins. The catalyst is sensitive to incoming contaminants (sulfur and water).
- Process steps:
 - Desulfurized feed and hydrogen are dried in fixed beds of solid dessicant prior to mixing together
 - The mixed feed is heated and passes through a hydrogenation reactor to saturate olefins to paraffins and saturate benzene
 - The hydrogenation effluent is cooled and passes through a isomerization reactor
 - The final effluent is cooled and separated as hydrogen and LPGs which typically go to fuel gas, and isomerate product for gasoline blending

Isomerization Process Schematic



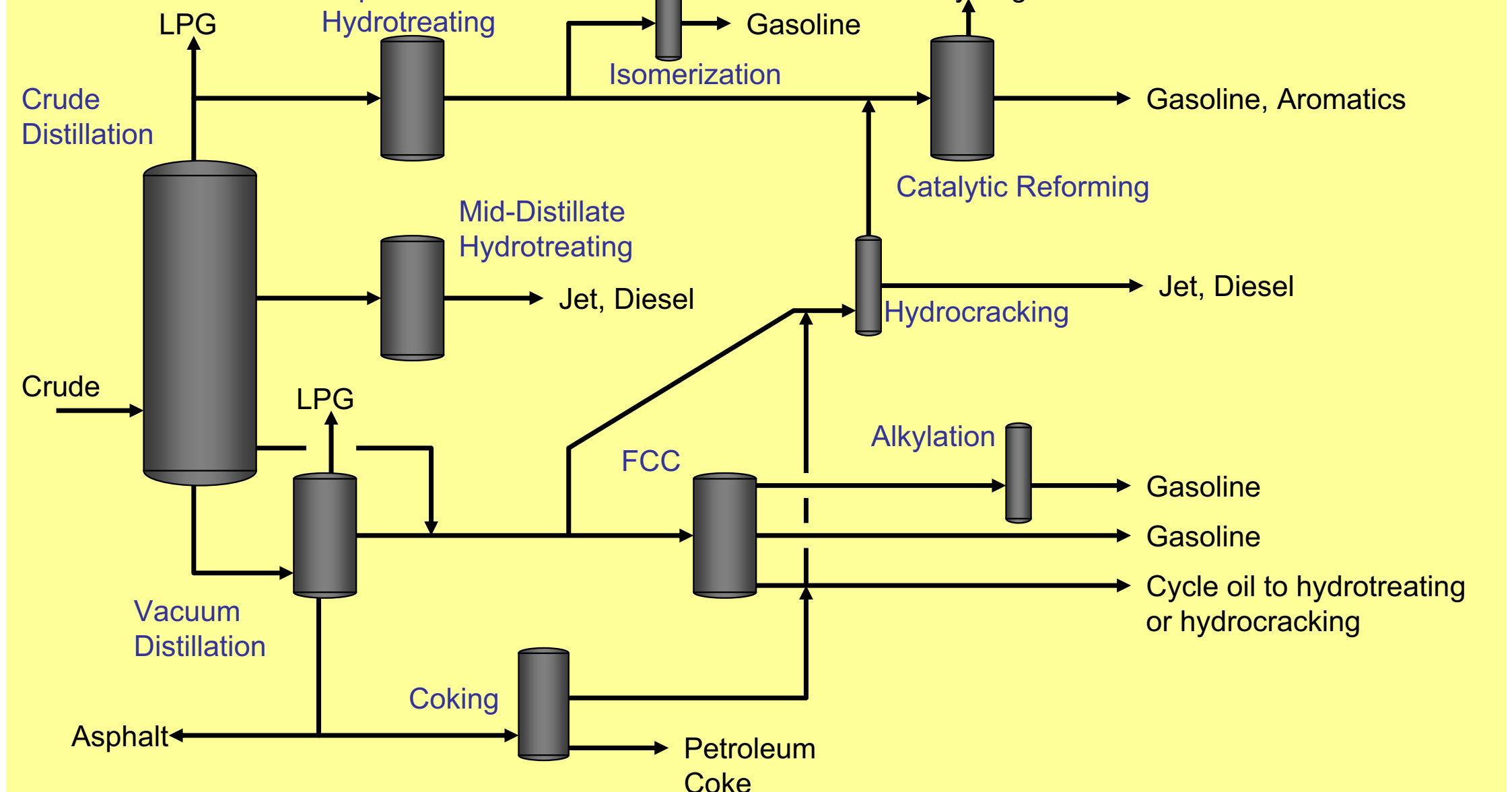
Isomerization Process

- Typical Yields and Dispositions

<u>PRODUCT</u>		<u>Disposition</u>
Hydrogen and Light ends		LPG, Fuel gas
Isomerate		Gasoline; iso-butane for Alkylation
Conversion	Up to 97%	

Naphtha

Hydrogen



1948 FCC and Crude Distillation



Liquefied Petroleum Gas (LPG), Liquefied Natural Gas (LNG) and Compressed Natural Gas (CNG)

Liquefied Petroleum Gas (LPG), Liquefied Natural Gas (LNG) and Compressed Natural Gas (CNG) are fossil derived fuels and therefore release, one way or another, sequestered greenhouse gases into the atmosphere.

As vehicle fuels, they are suitable for use in the two dominant internal combustion engine technologies; spark ignition and compression ignition. Although capable of working in either type of engine there are practical factors which limit their applications to one rather than the other. Broadly speaking LPG is compatible with petrol (gasoline) engines and LNG and CNG with heavy diesel vehicles.

Their main claims to fame are that they produce much less tailpipe pollution and can be significantly cheaper per mile to run especially in the UK where users can benefit from government grants, reduced excise duties and other charges. Many vehicles using these gases are dual fuel (aka bi-fuel) and there is a reasonable structure of filling stations, particularly for LPG; as a result they are practical and are 'here and now'.

Liquefied Petroleum Gas is a fuel which can power cars, buses and lorries, however due to factors discussed below, and other alternative fuels being available, LPG is best suited to light vehicles such as cars and small vans which normally run on petrol. Our estimate of energy density* is 65% compared to diesel and about 75% compared to petrol (gasoline).

Typically the gas is predominantly propane (C₃H₈) with some butane (C₄H₁₀) derived mainly from oil refineries (also North Sea gas, in the UK). We give the chemical formulae because it is the ratio of carbon to hydrogen which is important; the smaller the ratio of C to H, the better for the environment. It follows that methane (CH₄) is a better gas in this respect but only if fully burnt!

The gas is liquefied by moderate compression at normal temperatures and is stored in appropriate tanks and cylinders. The liquefaction is necessary to provide a reduction in volume and produce acceptable energy densities. In general this moderate, well tried, process gives it a portability and makes it a fuel with a myriad of applications but the main application discussed here is as a fuel for motor vehicles.

LPG vehicles need to be purpose built or they can be converted. It seems that conversions are only practically applicable to petrol vehicles, not diesel because diesel engines need significant modification for this particular gas. Normally they are Bi-fuel which means that they can be run on either LPG or petrol at the flick of a switch, even while motoring.

The most notable difference between LPG and petrol or diesel, for cars and vans, is the cost of fuel. As a rough guide, in the UK, the cost per gallon is halved compared to petrol, because the government have reduced the duty by a very substantial amount. In addition to this concession, DETR grants are also available to carry out conversions but they only apply to vehicles less than five years old: grants for cars and light vans were about £700 to £800 in 2004. We also noted in January 2005 that LPG vehicles, eligible for grants, (amongst other low exhaust-polluters) should qualify for 100% exemption from the London Congestion charge.

From a local environmental point of view LPG is cleaner than petrol and also diesel, although it is still a fossil fuel and thus its use, as a whole, contributes to global pollution and climate change. At the vehicle exhaust there are less CO, hydrocarbons, nitrous oxides and particulates emitted and it deposits less sulphur in the engine.

There are drawbacks to converting vehicles to LPG:

- The cost of conversion of a petrol car seems to work out at about £1,100 to £1,500 and it may take a few days to do (a few weeks lead time). According to *Andrew Frankel* in an article in the *Sunday Times* (13 Jan. 2002) the estimated cost was greater, from about £1,500 to £2,300. Whichever, the resultant capital outlay dictates that you must do a lot of miles to recoup the cost.
- There are relatively few filling stations around the UK, but no doubt more will become

available as there are more users (in January 2003 we read that there are well over a thousand stations).

- We have also heard of problems caused by non-standard filling nozzles.
- The mpg will be less than with conventional fuel (our guess is it will be reduced to about 3/4) but even so fuel costs should be lower, at about 2/3 [ie $1/2 \times 4/3 = 2/3$].
- The range of a tank full of LPG is likely to be less than a tank of petrol, however, with bi-fuel vehicles the total range will be the sum of the two so there is no need to be concerned about finding LPG stations.
- The extra volume taken up by the gas tank will reduce the available load space.
- There may be a slight performance deficit.
- You need to check that the manufacturers guarantee will not be invalidated and we suggest you check whether the insurance premiums will be increased.
- If your vehicle uses only leaded petrol the engine may require replacement of the valve seats.

Liquefied Natural Gas fuel (LNG) is produced from a mixture of raw components but is predominantly methane and is compatible with diesel technology, subject to the necessary modifications. Since the composition of methane is CH_4 , Natural Gas Vehicles (NGVs) are burning fuel with a relatively low carbon to hydrogen ratio. Our estimate of energy density is 60% compared to diesel.

LNG cannot be converted to a liquid by pressure alone but must be cooled to a very low temperature (lower than -160°C), a process which removes some impurities such as sulphur and water.

The LNG must be stored and transported permanently at around this temperature and this is accomplished by super insulation in a pressurised, double tank system, similar in principle to a thermos flask, together with a venting system to take away vapour. The storage pressure of about 8 bar (8 x atmospheric) is not regarded as very high but because of the insulation requirements the tanks are large, the fuel is only suited to large, heavy diesel vehicles such as trucks, buses and HGVs.

Although the energy density is about 60% compared to diesel the fuel costs are much lower and LNG should give lower running costs. Vehicle excise duties and road tax in the UK are reduced for natural gas vehicles and they are exempt from the London Congestion Charge providing they appear on the *Powershift* register.

When compared to diesel, NGVs are quieter and local emissions of pollutants are much reduced. The main drawback, global pollution associated with the burning of fossil fuels, is being addressed because the last few years have seen the growing use of biomethane or biogas (natural gas derived from organic and renewable sources, including waste) as the source of LNG and the same applies to CNG. See [this link](#) for more information on this use of biogas.

Compressed Natural Gas (CNG) is, as its name suggests, the close relative of LNG and as a natural gas it has the same basic characteristics. However, because it is not liquefied it has a lower energy density and is stored at very high pressures; about 200 bar. Our estimate of energy density is 25% compared to diesel or 42% compared to LNG.

These two factors are a big disadvantage for CNG. Storage and vehicle tanks have to be robust and heavy because of the high pressure requirement. The space taken up on the vehicles by the tanks is significantly more than twice that for LNG tanks (or the range is much less than half) because of the lower energy density.

Because it is Natural Gas it attracts financial incentives similar to LNG (details should be checked individually).

LNG is much more portable because CNG depots need to be supplied by pipeline and need compressors on site. LNG sites require much less capital investment and are more expensive to run.

It certainly seems that CNG is the poor relative of LNG but we can see evidence that it is used for heavy transport in the UK, on a limited number of prescribed highways.

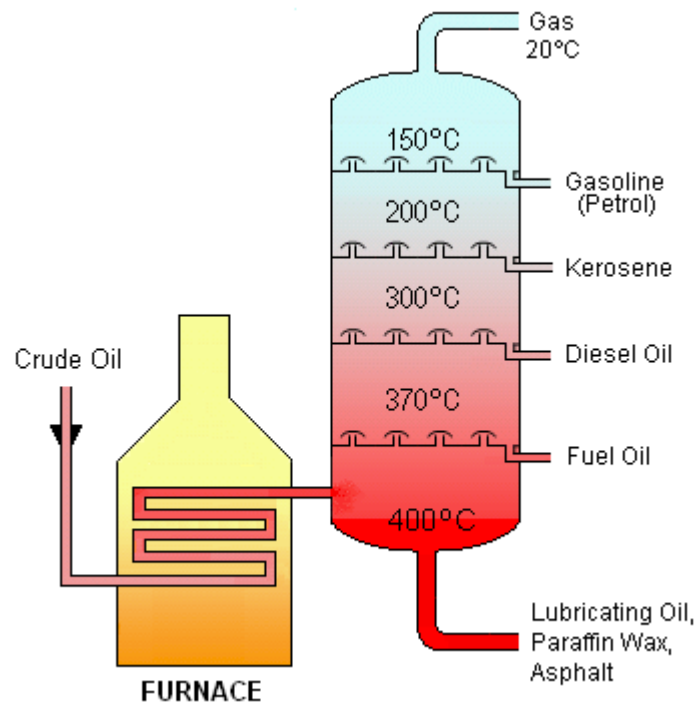
Liquefied Compressed Natural Gas (LCNG). This seems to be a marketing feature so that LNG refuelling stations have the ability to dispense two fuels, LNG and CNG at the same location. LNG can be pressurised and vaporised to give LCNG.

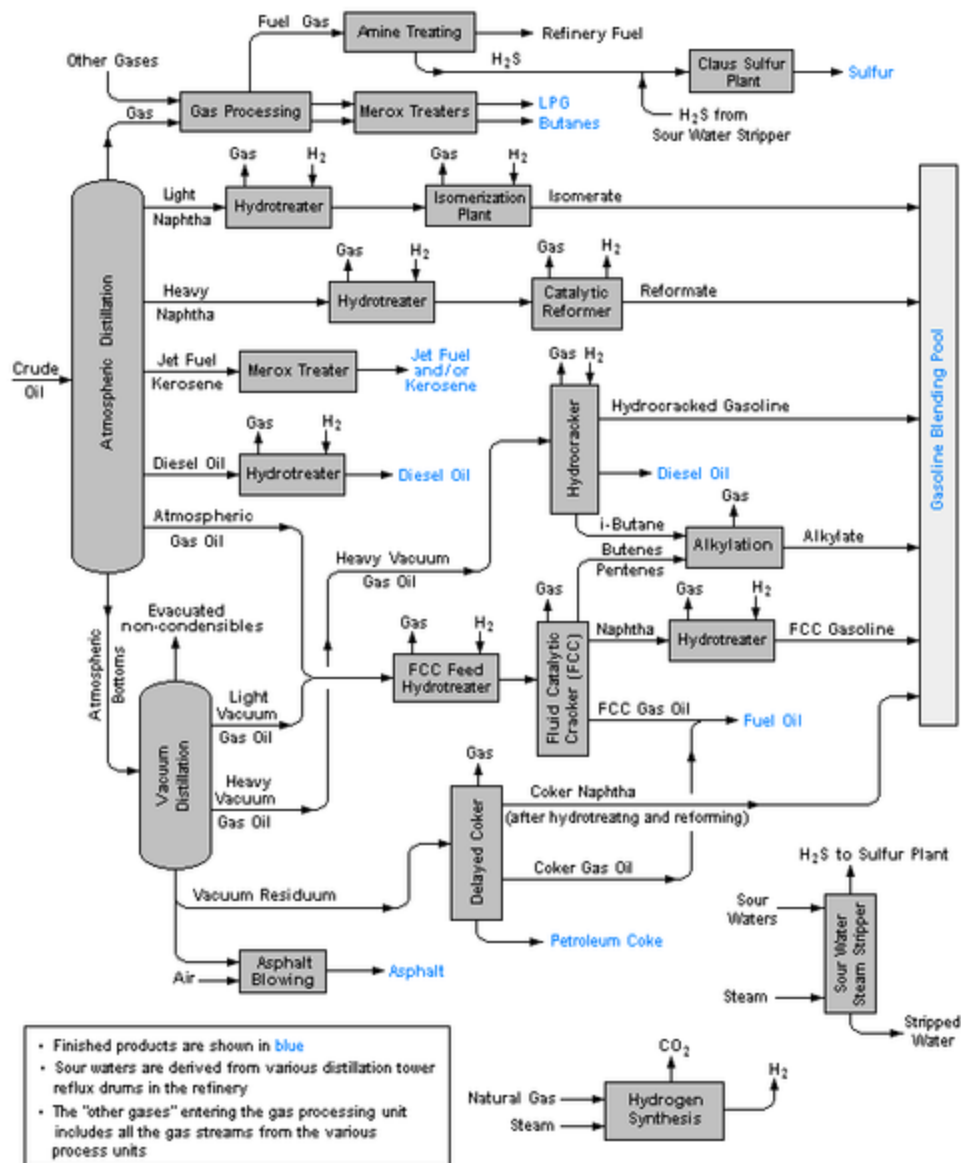
Summary: All of these gases can offer considerable reduction in pollution at the tailpipe, however, since they are fossil fuels in origin their continued use contributes to climate change. Although, in principle, they can be used to replace diesel or petrol, LPG is better suited as a petrol alternative for smaller vehicles such as cars and small vans and LNG and CNG are appropriate for larger diesel vehicles.

The fact that conversion of existing engines, using tried and tested methods, is practical (even if not without cost) together with acceptable energy densities makes the use of these fuels an immediate proposition. The fact that the raw supplies are those that exist already (oil and gas) is a practical point in their favour although the supplies will diminish since they are not renewable. The fuel distribution network has developed reasonably and is still growing and, we read that, the charging process (tank filling) made relatively easy. These factors have been bolstered by government financial incentives and other concessions so that adoption of the fuels has expanded to a significant level.

We have little doubt that vested interests have played their part in the evolution that has taken place. Indeed, reading the sometimes misleading articles from the vendors, which flaunt the advantages without mentioning the core drawback, tends to confirm this suspicion.

On balance we think it is better that vehicle operators are using these gases than sticking to the traditional petroleum fuels, but we believe that the government subsidies and concessions would have been better spent on alternatives such as biodiesel and organic alcohols





Common process units found in a refinery

- Desalter unit washes out salt from the crude oil before it enters the atmospheric distillation unit.
- Atmospheric distillation unit distills crude oil into fractions. See Continuous distillation.
- Vacuum distillation unit further distills residual bottoms after atmospheric distillation.
- Naphtha hydrotreater unit uses hydrogen to desulfurize naphtha from atmospheric distillation. Must hydrotreat the naphtha before sending to a Catalytic Reformer unit.
- Catalytic reformer unit is used to convert the naphtha-boiling range molecules into higher octane reformat (reformer product). The reformat has higher content of aromatics and cyclic hydrocarbons). An important byproduct of a reformer is hydrogen released during the catalyst reaction. The hydrogen is used either in the hydrotreaters or the hydrocracker.
- Distillate hydrotreater unit desulfurizes distillates (such as diesel) after atmospheric distillation.

- Fluid catalytic cracker (FCC) unit upgrades heavier fractions into lighter, more valuable products.
- Hydrocracker unit uses hydrogen to upgrade heavier fractions into lighter, more valuable products.
- Visbreaking unit upgrades heavy residual oils by thermally cracking them into lighter, more valuable reduced viscosity products.
- Merox unit treats LPG, kerosene or jet fuel by oxidizing mercaptans to organic disulfides.
- Coking units (delayed coking, fluid coker, and flexicoker) process very heavy residual oils into gasoline and diesel fuel, leaving petroleum coke as a residual product.
- Alkylation unit produces high-octane component for gasoline blending.
- Dimerization unit converts olefins into higher-octane gasoline blending components. For example, butenes can be dimerized into isooctene which may subsequently be hydrogenated to form isooctane. There are also other uses for dimerization.
- Isomerization unit converts linear molecules to higher-octane branched molecules for blending into gasoline or feed to alkylation units.
- Steam reforming unit produces hydrogen for the hydrotreaters or hydrocracker.
- Liquified gas storage units store propane and similar gaseous fuels at pressure sufficient to maintain them in liquid form. These are usually spherical vessels or bullets (horizontal vessels with rounded ends).
- Storage tanks store crude oil and finished products, usually cylindrical, with some sort of vapor emission control and surrounded by an earthen berm to contain spills.
- Slug catcher used when product (crude oil and gas) that comes from a pipeline with two-phase flow, has to be buffered at the entry of the units.
- Amine gas treater, Claus unit, and tail gas treatment convert hydrogen sulfide from hydrodesulfurization into elemental sulfur.
- Utility units such as cooling towers circulate cooling water, boiler plants generates steam, and instrument air systems include pneumatically operated control valves and an electrical substation.
- Wastewater collection and treating systems consist of API separators, dissolved air flotation (DAF) units and further treatment units such as an activated sludge biotreater to make water suitable for reuse or for disposal.[3]
- Solvent refining units use solvent such as cresol or furfural to remove unwanted, mainly asphaltenic materials from lubricating oil stock or diesel stock.
- Solvent dewaxing units remove the heavy waxy constituents petrolatum from vacuum distillation products

Major products

- Liquified petroleum gas (LPG)
- Gasoline (also known as petrol)
- Naphtha
- Kerosene and related jet aircraft fuels
- Diesel fuel
- Fuel oils
- Lubricating oils
- Paraffin wax
- Asphalt and tar
- Petroleum coke